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REVIEW ARTICLE

Clinical Effectiveness of Laser Acupuncture: A Systematic Review

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Abstract

The use of laser light as an alternative to needles to stimulate acupuncture points has been promoted for almost three decades. However, there has been no systematic assessment of the evidence to support the effectiveness of this form of acupuncture to date. A systematic review was therefore undertaken of RCTs evaluating laser acupuncture as a primary intervention. Relevant studies ($n=18$) were identified using computer-based literature searches and selected hand searches. Evidence was found to support the use of laser acupuncture in the treatment of myofascial pain, postoperative nausea and vomiting and for the relief of chronic tension headache. Laser acupuncture would appear to represent an effective form of acupuncture for the management of these conditions and could be considered as a viable alternative to more traditional forms of acupuncture point stimulation.

1. Introduction

Low intensity laser therapy (LILT) is a form of phototherapy which has been employed as a treatment for a variety of conditions, including musculoskeletal and soft tissue injuries and chronic ulceration [1–6]. Such lasers have also been recommended as an effective alternative to metal needles for the stimulation of acupuncture or musculoskeletal trigger points; this form of therapy is commonly termed “Laser Acupuncture” to distinguish it from the wider therapeutic applications of such laser devices [7,8]. Laser acupuncture is promoted as inherently safer than needle acupuncture due to the non-invasive nature of treatment (e.g., in cases of HIV infection) and as a method which is more appropriate for the stimulation of difficult points such as auricular acupuncture points (e.g., for smoking cessation) or

points around the perineum or genitals (e.g., for sexual dysfunction) [7].

Despite a long history of laser acupuncture as a therapeutic approach [9] and its apparent popularity, there has been no systematic approach to the development of research in this area. Furthermore, the lack of an obvious mechanism of action (particularly given lack of any sensation during laser treatment), coupled with inconsistent reports of clinical effectiveness, has resulted in skepticism [10].

To date, there have been no systematic reviews of the evidence in this area; the current study was therefore undertaken with the aim of determining the evidence base for the clinical effectiveness of laser acupuncture. Specific objectives for this systematic review were:

- (i) to identify randomized-controlled studies assessing the clinical effectiveness of laser

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- acupuncture, principally for the reduction of pain of musculoskeletal origin;
- (ii) to make conclusions on the strength of the evidence supporting the use of laser acupuncture; and
- (iii) to investigate the potential relevance of treatment parameters to reported outcomes, in particular to assess the evidence for an optimal treatment protocol.

2. Methods

A systematic review was undertaken of the evidence to support the clinical effectiveness of laser acupuncture from Randomized Controlled Trials (RCTs) in keeping with good practice guidelines produced by the World Association for Laser Therapy (WALT) [11].

3. Selection Criteria

3.1. Types of study

Only RCTs published in the English language were included in this review; studies employing a randomized cross over design were excluded, as this was considered an inappropriate design for the assessment of effectiveness of laser acupuncture.

3.2. Types of participants

Studies based upon treatment of adults (> 18 years) with soft tissue injury, an acute or chronic pain condition or any systemic illness were included.

3.3. Types of intervention

Articles evaluating laser acupuncture as the primary intervention were included. Laser acupuncture was defined as the application of low intensity laser radiation (i.e., non-thermal intensities) to classical meridian points or trigger points. Studies in which the primary treatment involved needling, acupressure, Sham laser acupuncture or non-acupuncture application of low intensity laser therapy were excluded. Acceptable control interventions were: no treatment, placebo or sham laser, other sham procedure, or other therapeutic intervention.

3.4. Types of outcome

RCTs were included that used at least one of the following outcomes: pain intensity (visual analogue scale; VAS), or a global measure of patient improvement (overall improvement, proportion of patients recovered, subjective improvement of symptoms).

For those trials including subjects with non-painful illnesses, the primary outcome measure was considered for its appropriateness to the presenting condition.

3.5. Search strategy and selection of studies

Relevant studies were identified with a computer-based literature search using seven key words/phrases (laser, laser therapy, laser acupuncture, LLLT, pain, soft tissue, injury) on the following databases on OVID: Sports discus (1960–2005), Medline (1966–September 2005), EMBASE (1980–September 2005), CINAHL (1982–September 2005), British Nursing Index (1985–September 2005), AMED (1985–September 2005). In addition, a series of 31 small searches were performed on PubMed (1966–September 2005), by combining 13 key words (low level laser, laser acupuncture, LLLT acupuncture, laser, LLLT, laser therapy, injury, pain, soft tissue, strain, sprain, musculoskeletal, rheumatic) using Boolean logic (AND).

More limited searches were undertaken on the Physiotherapy Evidence Database (PEDro; 1966–April 2005) and Acubriefs (www.acubriefs.com) using one key word (laser). This was supplemented with a related articles search on PubMed and citation tracking of relevant primary and review articles ($n=35$), and all incoming full text papers ($n=134$). In addition a convenience search of one key journal was performed (*Laser Surgery Medicine* 1994–2005).

In the first stage of selection, titles and abstracts of all studies were assessed for the above eligibility criteria. If it was clear from information provided in the title and/or abstract that the study was not relevant it was excluded; if it was unclear from the available abstract and/or title, the full text article was retrieved. Full text articles were also retrieved for studies with a relevant title, but no available online abstract. There was no blinding to study author, place of publication or results. One author (CB) assessed the content of all full text articles, making the final inclusion/exclusion decisions.

3.6. Assessment of methodological quality

Methodological quality of each RCT was independently assessed by two authors (CB, SMCD). Review authors were not blinded with respect to authors, institution or journal. Consensus was used to resolve disagreements and the third author was consulted if disagreements persisted (GDB). The methodological quality of the RCTs was assessed by using the van Tulder scale [12]. Each item was scored 'yes', 'no' or 'don't know' according to the definitions of the criteria (see Table 1).

Table 1 Summary of quality ratings: van Tulder scores

Included study	Criteria fulfilled	Total score
Lundeberg, 1987 [34]	D E F I J	5
Waylonis, 1988 [27]	G H J	3
Snyder-Mackler, 1989 [24]	A D E G J	5
Ceccherelli, 1989 [29]	D E I J	4
Haker, 1990 [20]	D E G H I J	6
Haker, 1991 [21]	D E F G H I J	7
Laaskso, 1997 [28]	D E G J	4
Schlager, 1998 [22]	C D F G H I J	7
Yiming, 2000 [19]	C D F H I J	6
Radmayr, 2001 [39]	C H I J	4
Gur, 2002 [25]	A G H I J	5
Hakguder, 2003 [30]	C F G I J	5
Gur, 2004 [23]	A C D G I J	6
Ilbuldu, 2004 [31]	C F G H	4
O'Reilly, 2004 [40]	D E I J	4
Butkovic, 2005 [38]	C G H I J	5
Altan, 2005 [32]	C F G J	4
Ebneshahidi, 2005 [26]	G I J	3

Higher quality studies (≥ 6) represented in **bold**.

Key: van Tulder Internal Validity Criteria

A. Was the method of randomization adequate?

B. Was the treatment allocation concealed?

C. Were the groups similar at baseline regarding the most important prognostic indicators?

D. Was the patient blinded to the intervention?

E. Was the care provider blinded to the intervention?

F. Was the outcome assessor blinded to the intervention?

G. Were co-interventions avoided or similar?

H. Was the compliance acceptable in all groups?

I. Was the dropout rate described and acceptable?

J. Was the timing of the outcome assessment in all groups similar?

K. Did the analysis include an intention to treat analysis?

Studies were classified into low or high quality: high quality was defined as a trial fulfilling six or more of the 11 methodological criteria; and this classification was used to grade the strength of the evidence.

3.7. Data extraction and analysis

One author (CB) extracted data on the study characteristics: study population, interventions, analyses and outcome. Studies were first assessed for clinical homogeneity with respect to the nature of the disorder, control group and the type and timing of outcomes. Studies were divided and analyzed as follows:

3.7.1. Nature of disorder

The primary focus of this review was musculoskeletal pain; this included myofascial pain and soft tissue injuries (including laser applied to trigger points, as well as to traditional acupuncture points). In addition, relevant papers detailing laser acupuncture treatment of other conditions were included as a secondary focus for the current review.

3.7.2. Control group

Acceptable control or comparison groups included: no treatment, placebo/sham laser acupuncture; needle acupuncture; acupressure; other interventions not including laser treatment.

3.7.3. Outcome measures

Acceptable outcome measures included: pain, global function or (for 'other conditions') a relevant primary outcome measure.

3.7.4. Follow up

Relevant details on any follow ups were noted.

3.7.5. Outcomes

Means and standard deviations for outcome measures were extracted and (where possible) individual study-effect estimates were calculated using *RevMan* software. This took the form of standardized mean differences (SMD) for continuous data

[13] or risk ratios (RR) for dichotomous data, each with 95% confidence intervals (95% CI) [14]. When effect size could not be calculated (for example: no information about standard deviation was provided) a qualitative analysis was performed.

3.7.6. Levels of evidence

In addition, for the purposes of interpretation of results, the following levels of evidence were used [12,15]:

- *Strong evidence*: consistent findings among multiple higher quality RCTs;
- *Moderate evidence*: consistent findings among multiple lower quality RCTs and/or one higher quality RCT;
- *Limited evidence*: one lower quality RCT;
- *Conflicting evidence*: inconsistent findings among multiple RCTs; and
- *No evidence*: no RCTs.

3.8. Adequacy of treatment/clinical appropriateness

Two authors (GDB, CB) independently extracted the following details concerning the laser dosage parameters: wavelength, area of treatment, power, dosage per treatment point (where necessary derived from time of application) and, where possible, total dosage. The accuracy and clinical appropriateness of the treatment dose was assessed by one

author who has researched and published widely in the area of laser therapy (GDB), using the recommendations of the WALT as a guideline (www.walt.nu) [16]. The adequacy of the choice of acupuncture point, relative to each condition, was assessed by an experienced acupuncturist (SMcD) based upon established guidelines [17].

4. Results

4.1. Study selection

Figure shows the Quality of Reporting of Meta-Analysis (QUOROM) statement flow diagram [18] summarizing the process of study selection and the number and reason for exclusion of studies at each stage. From the initial examination of citations yielded through the literature search, 133 studies were included. After review of the complete texts, 115 studies were excluded, leaving 18 eligible randomized controlled trials for inclusion in the current review; of these trials, of which 12 investigated the effectiveness of laser acupuncture in relieving pain.

4.2. Study quality (Table 1)

There were five ‘high quality’ studies in the included trials [19–23]; the remaining thirteen studies scored less than 6/11 on the van Tulder scale and were categorized as ‘low quality’. There were

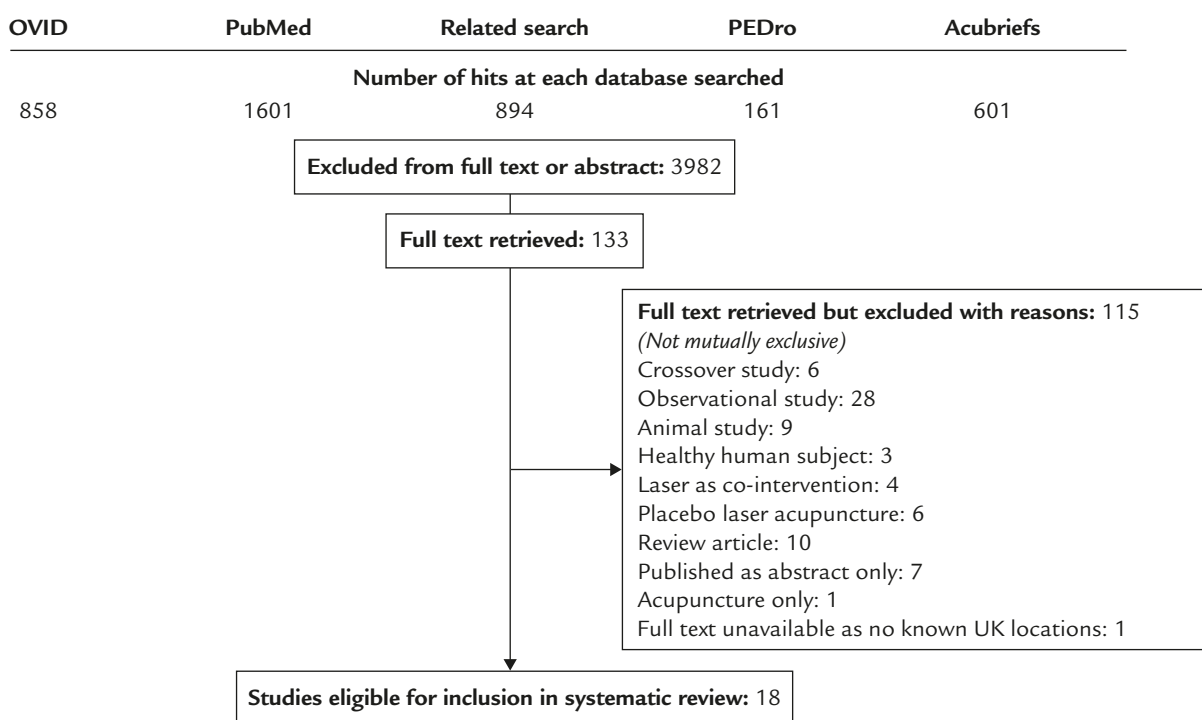


Figure QUOROM flow diagram.

several criteria which consistently limited the quality of studies: none of the included 18 studies carried out allocation concealment or intention-to-treat analysis adequately; only three [23–25] were considered to have performed a sufficient randomization procedure.

4.3. Study characteristics

Study characteristics are summarized in Tables 2 and 3.

4.4. Outcome measures

Four studies [21,26–28] failed to provide sufficient data for any of the key outcome measures and it was not possible to calculate individual study effect estimates (either SMD or RR).

4.5. Clinical appropriateness of laser acupuncture treatments

Assessment of the clinical appropriateness of treatments employed within the reviewed trials was confounded by the lack of detail in some published papers. Beyond this, it is noteworthy that those studies reporting negative results (no significant benefit of laser acupuncture compared with control or sham conditions) were all associated with lack of detail on treatments employed or the use of inappropriate treatment parameters, including insufficient laser power outputs or dosages (for detail see Tables 2 and 3).

4.6. Clinical effectiveness of laser acupuncture: musculoskeletal pain (see Table 2)

4.6.1. Myofascial pain/musculoskeletal trigger points

The effectiveness of laser acupuncture in the treatment of myofascial pain or musculoskeletal trigger points affecting the neck, shoulder, thoracic or lumbar spine was investigated in the majority of studies reviewed ($n=9$); seven of these reported positive outcomes in favor of laser acupuncture [19–21, 28–31]. The number of treatment sessions in the studies ranged from 10 to 12 and all incorporated at least one measurement of pain at the end of the treatment period. The majority of studies also included some form of follow up assessment, although the longest period for such review was only 3 months. Irradiation parameters used in these studies varied markedly: power outputs ranged from 0.95 mW to 25 mW and doses from 0.57 J to 5 J per point. In the two studies which reported negative results (no

significant differences between active and placebo irradiation) [32], it was not possible to determine the actual laser irradiation parameters used by researchers. However, it was estimated that both of these groups failed to employ appropriate power outputs and dosages per point: for Waylonis et al [25] dosage was estimated at <0.075 J point and in the case of Altan et al [32], the clinical appropriateness of dosages employed by this research group have been challenged previously [33].

It was therefore concluded that there is moderate evidence that laser acupuncture, is effective at reducing myofascial pain—at least when applied at certain irradiation parameters.

4.6.2. Lateral epicondylitis (Tennis elbow)

Haker and colleagues completed three early placebo-controlled studies on the potential effectiveness of laser acupuncture in lateral epicondylitis (tennis elbow) [20,21,34], the latter two of which were rated as ‘high quality’ [21,22]. The first of these studies used a combination of laser systems (632.4 nm and 904 nm; 0.042 J and 0.0936 J, respectively) to 10 points and failed to find any clinical benefits at the end of the treatment period in any of the outcome measures used (including VAS for pain) [34]. This group also monitored nerve conduction in treated subjects and found a small but significant increase in latencies 15 minutes after irradiation, which they attributed to immobilization of the subjects’ limbs during the investigation. However, this finding of increased latencies has been reported by other groups investigating the physiological effects of laser irradiation in healthy human volunteers [35–37]. In the second study by this group, laser was applied to five acupuncture points using a 904 nm infrared system to deliver a higher dose of 0.36 J per point [20]. After 10 treatment sessions, there were no significant differences between groups in terms of pain (RR 3.09; 0.88 to 10.38); in addition, no significant differences were reported at follow ups recorded at 3 months (RR 0.9; 0.29 to 2.85) and 1 year (RR 1.63; 0.36 to 7.33). Furthermore, no significant changes were seen between groups in terms of the functional outcome measure used (grip strength). In a further study by this group [21], a combination of visible and infrared laser in a multisource array unit was used to treat the tender area of the elbow, in addition to a pen probe laser applied to two acupuncture points (LI11, 12). This treatment combination again failed to show any improvement in terms of pain or function when compared with the placebo group after a series of 10 treatments (RR 0.55; 0.15 to 1.93) and at 3 months follow up (RR 0.85; 0.28 to 2.52).

Table 2 Summary of study characteristics: laser acupuncture for painful conditions

Study	Participants	Groups/ intervention	Outcomes	Comment
Lundeberg et al [34]	Lateral epicondylitis (Tennis elbow) <i>n</i> =57 (31 male, 26 female; mean age 43 yrs, 25–62 yrs)	A. Placebo (<i>n</i> =19) B. GaAs laser (<i>n</i> =19) Laser parameters: Wavelength: 904 nm Pulsed: 73 Hz Power output: 0.07 mW Dose: 0.042 J point × 10 points C. He Ne laser (<i>n</i> =19) Laser parameters: Wavelength: 632.4 nm Continuous wave Power output: 1.56 mW Dose: 0.0936 J point × 10 points All groups: Acupuncture points: LI10, LI11, LI12, SJ5, SJ10, SI4, SI8, H3, H4, P3 non-contact technique. <i>n</i> =10 treatments; ×2 sessions/wk; 5–6 wks	Outcome measures: Visual Analogue Scale (VAS) Pain Pain on wrist dorsiflexion Pain on weight/load Grip strength Patient and medical assessment of outcome Nerve conduction studies also performed Follow up: End of intervention; follow up continued for 3 mo. Postal questionnaire at 6 mo Results: No significant change in any outcome Authors' conclusion: Negative	Acupuncture points: Appropriate Laser parameters: Inappropriate Power output too low Dosages too low Non contact technique inappropriate
Waylonis et al [27]	Chronic myofascial pain/fibromyalgia <i>n</i> =62 subjects (6 male, 56 female)	Four groups with two series of five treatments sessions 6 wks apart: A. Placebo: Placebo B. Laser acupuncture: Placebo C. Placebo: Laser acupuncture D. Laser acupuncture: Laser acupuncture Laser: Wavelength: 632.8 nm Continuous wave Power output: not specified Dose: not specified '15s point' ×12 acupuncture points (hand–hoku point, cervical, dorsal and shoulder acupuncture points—exact points not stated) Placebo treatment based upon a 'point finder'—unspecified output	Outcome measures: McGill pain questionnaire Detailed questionnaire: medication use, effect on work, recreational performance Follow up: Series 1: baseline, 6 wks post completion? Series 2: baseline, 6 wks post completion, 60 days, 120 days Results: No significant differences between groups at any time point Authors' conclusion: Negative	Acupuncture points: Unclear Laser parameters: Unclear/ Inappropriate Insufficient data: dosage liable to have been too low (15s point, <5 mW) Estimated at <0.075 J point
Snyder-Mackler et al [24]	Myofascial trigger points (neck and back)	A. Laser (trigger point) Acupuncture (<i>n</i> =13)	Outcome measures: Skin resistance	Trigger points: Appropriate

<p>n=24 patients with points in the neck (10) or low back (14)</p>	<p>B. Placebo (n=11) Laser parameters: Wavelength: 632.8 nm Continuous wave Power output: 0.95 mW Dose: 0.019 J point × 3 each trigger points (×3 20s applications of laser or placebo irradiation) Number of trigger points unclear Additional treatments: 12 subjects (six per group received hot packs and high voltage pulsed current)</p>	<p>Visual Analogue Scale (VAS) Pain Follow up: Pre- and post-treatment during each session Results: Significant increase in skin resistance ($p<0.001$) and decrease in pain ($p<0.005$) following laser treatment. No significant correlation between skin resistance and pain. No means/SD, Authors' conclusion: Positive</p>	<p>Laser parameters: Unclear /Appropriate Dosage potentially appropriate assuming ×3 applications of 0.19 J per point (total 0.57 J point)</p>
<p>Ceccherelli et al [29] Myofascial pain in cervical region (affecting splenius, sternocleidomastoid, levator scapulae, supraspinatus) n=27 females</p>	<p>A. Laser (n=13); 43.7 ± 12.8 yrs) B. Placebo (n=14; 49.6 ± 9.1 yrs) Laser parameters: Wavelength: 904 nm Pulsed: 1000 Hz/200 ns Power: peak power: 25 W Dose: 1 J point; total 5 J, Five bilateral homometameric acupoints: LI4, LI11 LI14, SI3 small intestine, triple burner 5. All groups: ×3 sessions/wk on alternate days, total 12 sessions</p>	<p>Outcome measures: McGill pain questionnaire Visual Analogue Scale (VAS) Pain Follow up: End of treatment, 3 mo post treatment Results: Significant decrease in pain after treatment, and at 3 mo follow up in favor of laser group. Effect size: Pain (VAS) Post Rx SMD: 27.5 (16.3–38.9); 3 mo: SMD: 27.1 (16.6–37.6) Authors' conclusion: Positive</p>	<p>Acupuncture points: Appropriate Laser parameters: Appropriate</p>
<p>Haker et al [20] Lateral epicondylitis (duration of symptoms 1–36 mo) n=49 (28 male, 21 female; mean age 46.7 yrs)</p>	<p>A. Laser acupuncture (n=23) B. Placebo (n=26) Laser parameters: Wavelength: 904 nm Pulsed: 70 Hz/180 ns Power: average power: 12 mW Peak power: 8.3 W Dose: 0.36 J point, acupoints: LI, LI10, LI11, LI12, Lu 5 and SJ 5. *Non-contact treatment (1 mm) All groups: ×2–3 sessions/wk, total 10 treatments</p>	<p>Outcome measures: Verbal/Numerical Rating Scale (Pain) Vigrometer (grip) test (Function) Follow up: End of treatment, 3 mo and 1 yr post treatment Results: No significant differences at any point Drop outs: 10 treatments: Laser n=1, Placebo, n=1; 3 mo: Laser n=5, Placebo n=4. Effect size: Pain post Rx: RR. 3.09 (0.88–10.38) placebo group Authors' conclusion: Negative</p>	<p>Acupuncture points: Appropriate Laser parameters: Inappropriate Power output potentially appropriate; dosage too low; non-contact technique inappropriate</p>

(Contd)

Table 2 Continued

Study	Participants	Groups/Intervention	Outcomes	Comment
Haker et al [21]	Lateral epicondylitis <i>n</i> =60; 58 with lateral epicondylitis	<p>A. Laser (<i>n</i>=29; 18 male, 11 female; mean age 45.6; range 34–57 yrs)</p> <p>B. Placebo (<i>n</i>=29; 25 male, 4 female; mean age 45; range 33–65 yrs)</p> <p>Laser parameters: Wavelength: 632.8 nm Continuous wave Power output: 5 mW (70 mrad) Dose: 0.6 J point, acupoints: LI11, LI12 All groups: ×3–4 sessions/wk, total 10 treatments</p> <p>Additional treatments: Laser therapy (Affected area) Wavelength: 904 nm Pulsed: 3800 Hz/180 ns Power output: 4 mW average × 5 diodes Peak power: 10 W (70 mrad) Dose: 1.92 J per diode. No other treatment used; medication use was prescribed during treatment and follow up period</p>	<p>Outcome measures: Verbal/Numerical Rating Scale (Pain) Vigorimeter (grip) test (Function) Follow up: End of treatment, 3 and 6 mo and 1 yr post treatment Results: No significant differences at end of treatment. Significant differences in favor of the placebo treatment at follow up in terms of grip strength ($p<0.06$) Drop outs: 3 mo: Laser <i>n</i>=2, Placebo <i>n</i>=3; 6 mo: Laser <i>n</i>=6, Placebo <i>n</i>=9; 1 yr: Laser <i>n</i>=6, Placebo <i>n</i>=11. Effect size: Pain post Rx: RR: 0.55 (0.15–1.93) Authors' conclusion: Negative</p>	<p>Acupuncture points: Appropriate Limited Laser parameters: Inappropriate Power output too low Confounding influence of laser therapy treatment to lateral epicondyle</p>
Laasko et al [28]	Myofascial trigger point pain at the neck, shoulders and upper thoracic regions. Lasting at least 6 mo (mean 8.2 yrs) <i>n</i> =41 subjects (mean age 42.2 yrs; 8 male, 33 female)	<p>A. Laser low dose/red (<i>n</i>=8) Wavelength: 670 nm Pulsed: 5000 Hz Power output: 10 mW/spot size: 0.036 cm² Dose: 1 J cm⁻² point</p> <p>B. Laser high dose/red (<i>n</i>=7) Wavelength: 670 nm Pulsed: 5000 Hz Power output: 10 mW/spot size: 0.036 cm² Dose: 5 J cm⁻² point</p> <p>C. Laser low dose/IR (<i>n</i>=8) Wavelength: 820 nm</p>	<p>Outcome measures: Visual Analogue Scale (Pain) Follow up: Immediately before and after each treatment session Results: Significant reductions in trigger point pain, in all laser groups and in placebo groups; however reductions greater in laser group. Summary data not given Authors' conclusion: Positive</p>	<p>Trigger points: Appropriate Laser parameters: Appropriate</p>

Gur et al [25]	Fibromyalgia n=40 female patients	<p>Pulsed: 5000Hz Power output: 25mW/spot size: 0.028cm² Dose: 1 J cm-2 point D. High dose/IR laser (n=8) Wavelength: 820nm Pulsed: 5000Hz Power output: 25mW/spot size: 0.028cm² Dose: 5 Jcm-2 point E. Placebo 'Low dose' (n=5) All groups: Three most tender trigger points treated; ×3 sessions/wk (wk 1) ×2 sessions/wk (wk 2) All laser outputs checked</p>	<p>Outcome measures: Pain Number of tender points Skin fold tenderness Sleep disturbance Muscular spasm Fatigue (ordinal Likert scale; 0-4) Follow up: Immediately before and after treatment</p>	<p>Tender points: Appropriate Laser parameters: Appropriate</p>
Hakguder et al [30]	Myofascial pain syndrome (neck and upper back pain) with the presence	<p>A. Laser and exercise (n=31; 22 female, 9 male; mean age 37.3 ± 10.1 yrs) B. Exercise only</p>	<p>Results: No significant differences between groups pre-treatment. Post treatment, the active laser group had a significantly lower amount of pain, muscle spasm, morning stiffness, tender point number ($p < 0.05$) Effect size: Post Rx Pain: 1.17 (0.63-1.71) Authors' conclusion: Positive</p>	<p>Tender points: Appropriate Laser parameters: Appropriate</p>

(Contd)

Table 2 Continued

Study	Participants	Groups/Intervention	Outcomes	Comment
	of one Trigger Point $n=62$ subjects (aged 18–60 yrs)	($n=31$; 24 female, 7 male; mean age 34.2 ± 10.2) Laser parameters: Wavelength: 780nm Continuous wave Power output: 5mW/Spot Diameter 0.5cm Dose: 0.98 J point, 5 J cm ⁻² ; 10 daily sessions All groups: Exercise regime of daily gradual slow stretching of trapezius and levator scapula: 10 times/day for 10 days	Thermography Follow up: Immediately post treatment, 3 wks post treatment Results: Significant differences in laser group in terms of pain, MPT, thermographic difference immediately after treatment and at 3 wks follow up. Effect size: Pain post Rx: 2.36 (1.36–3.36) Authors' conclusion: Positive	
Gur et al [23]	Myofascial pain syndrome in the neck/shoulder region (between 1 and 10 tender/ trigger points) $n=60$ subjects (11 male, 59 female; aged 31.7 ± 9.3 yrs)	A. Laser ($n=30$; mean age 32.2 ± 8.43 yrs) B. Placebo ($n=30$; 30.9 ± 9.4 yrs) Laser parameters: Wavelength: 904nm Pulsed: 2800Hz/200ns Power output: Average 11.2mW Peak Power: 20W Dose: 2 J cm ⁻² point; 20 J cm ⁻² maximum of 10 trigger points) All groups: Treated daily for 2 wks (except weekends)	Outcome measures: Mean number of trigger points Pain at rest/movement Self assessed improvement of pain Neck pain disability scale (NPDS) Beck depression inventory (BDI) Nottingham health profile (NHP) Follow up: Weeks 2, 3 and 12 Results: Significant differences in: Mean number of trigger points ($p<0.01$) favoring laser at all follow ups Pain ($p<0.01$) decreased versus baseline at all follow ups in Laser; Week 2 only in Placebo NPDS, NHP, BDI ($p<0.01$) in favor of Laser at all follow ups except week 12 (NHP) Effect size: Pain: 2 wks 2.28 (0.69–3.87); 12 wks 2.02 (0.81–3.23) Authors' conclusion: Positive	Tender points: Appropriate Laser parameters: Appropriate
Ilbuldu et al [31]	Trigger point pain in upper trapezius	A. Placebo laser (32.4 ± 6.9 yrs) $\times 3$ sessions/wk; total 12 sessions	Outcome measures: Visual Analogue Scale (Pain) Authors' conclusion: Positive	Tender points: Appropriate

Altan et al [32]	Myofascial pain in cervical region <i>n</i> =53 patients (35 female, 18 male)	<p>B. Dry needling (35.3 ± 9.2 yrs) To upper trapezius, ×1 session/wk for 4 wks C. Laser (33.9 ± 10.4 yrs) Wavelength: 632.8 nm Continuous wave Power output: not specified Dose: 2 J point, ×3 points on trapezius bilaterally 3 sessions/wk, total 12 sessions Additional treatments: Stretching exercises for upper, middle trapezius and pectorals performed at home Paracetamol prescribed</p>	<p>Rest and activity Analgesic consumption Cervical Range of Movement (ROM) Nottingham Health Profile (NHP) Follow up: Immediately after treatment, 6 mo post treatment Results: Significant decreases in pain (at rest and on activity), ROM, NHP immediately post treatment. No significant differences between groups at 6 mo. Effect sizes: Pain post Rx: $2.65 (1.35-3.95)$; 6 mo: $0.87 (-0.89-2.63)$; NHP: $8.76 (0.36-17.88)$; 4.23 ($-5.38-13.84$) Authors' conclusion: Positive</p>	<p>Laser parameters: Appropriate</p>
		<p>A. Laser (<i>n</i>=23; 20 female, 3 male) B. Placebo (<i>n</i>=25; 12 female, 13 male) Laser parameters: Wavelength: 904 nm Pulsed: 1000Hz/180ns Power output: Peak power available of 27 W, 50 W or 27×4W; average power output not specified Dose: unclear: 2 min over each point/day for 10 days over a 2 wks period × 3 trigger points bilaterally, and one point in the taut bands in trapezius muscle bilaterally Additional treatment: All groups: Daily isometric exercises and stretching just short of pain for 2 wks at home</p>	<p>Outcome measures: Pain Algomerty Cervical lateral flexion Follow up: Immediately after treatment, 12 wks later (week 14) Results: 48 patients completed evaluation (32 female, 16 male). Significant improvement in all parameters for both groups (within group analysis). Comparison of the percentage changes did not show significant differences relative to pretreatment values (between group analyses). Effect size: Pain post Rx: $0.05 (0.02-0.08)$ Authors' conclusion: Negative</p>	<p>Tender points: Appropriate Laser parameters: Unclear/ Inappropriate</p>

Table 3 Summary of study characteristics: laser acupuncture for other conditions

Study	Participants	Groups/intervention	Outcomes	Comment
Schlager et al [22]	Post-operative nausea and vomiting <i>n</i> =40 children (aged 3–12 yrs) undergoing strabismus surgery	<p>A. Laser acupuncture [age 5.9 yrs (1.8); 9 male, 11 female]</p> <p>B. Placebo [age 6.3 (1.9); 10 male, 10 female]</p> <p>Laser parameters: Wavelength: 670 nm Continuous Wave Power: 10 mW Dose: 0.3 J point; P6 points bilaterally; 15 min before induction of anesthesia and 15 min after arriving in the recovery room Placebo group: laser not activated All patients: Oral premedication Oral strabismus performed under general anesthetic</p>	<p>Outcome measures: Incidence of vomiting over 24 hrs</p> <p>Results: In the laser stimulation group, the incidence of vomiting was significantly lower (25%) than that in the placebo group (85%) Laser: vomiting 5; non-vomiting 15 Placebo: vomiting 17; non-vomiting 3 Authors' conclusion: Positive</p>	<p>Acupuncture points: Appropriate</p> <p>Laser parameters: Appropriate</p>
Yiming C et al [19]	Adolescent smokers (aged 12–18 yrs, 3 mo of smoking experience) <i>n</i> =268 (200 male, 68 female)	<p>A. Laser acupuncture treatment (<i>n</i>=128) Laser parameters: Wavelength: 632.8 nm Power output: 25–3 mW Dose: Unclear Acupoints: Ershenmen, Ko, Fei, Waibi on the left ear 60s per point. <i>n</i>=12 treatments; ×3 sessions/wk</p> <p>B. Sham acupuncture (control) (<i>n</i>=140) As above—no laser emitted</p>	<p>Outcome measures: Smoking cessation (defined as complete cessation) Carbon monoxide smoker lyser test carried out after the 7th and 11th treatments Follow up: End of intervention; follow up at 3 mo</p> <p>Results: Smoking cessation after completing treatment for 4 wks were 21.9% in Laser acupuncture group and 21.4% in the sham acupuncture group At 3 mo post-treatment, the rates for complete cessation were 24.8% and 26.2%, respectively. There were no significant differences in smoking cessation in between groups Drop out: <i>n</i>=62 failed to complete a minimum of six treatment sessions.</p>	<p>Acupuncture points: Appropriate</p> <p>Laser parameters: Unclear</p>

Radmayr et al [39]	Nocturnal enuresis. n=40 children aged over 5 yrs presenting with primary nocturnal enuresis underwent a previous evaluation of their voiding function to assure normal voiding patterns and a high night time urine production	A. Desmopressin B. Laser acupuncture Details not provided	Laser acupuncture: n=32, Sham acupuncture: n=30. In total: 19% drop out Authors' conclusion: Negative	Outcome measures: Frequency of bedwetting/ Dry nights Complete cessation Follow up: Re-evaluation at 6 mo Results: Complete success rate of 75% in the desmopressin-treated group. Additional 10% of the children had a reduction of their wet nights of more than 50%. In laser acupuncture group, 65% of the randomized children were completely dry. Another 10% had a reduction of the enuresis frequency of more than 50% per week. 20% of the children in the desmopressin-treated group did not respond at all as compared with 15% in the acupuncture-treated group However statistical evaluation revealed no significant differences among the response rates in both groups Authors' conclusion: No difference	Acupuncture points: Unclear Laser parameters: Unclear
O'Reilly et al [40]	Interstitial cystitis n=56 women	A. Laser acupuncture Unclear: self-applied daily for 30 secs over the SP6 acupuncture point for 12 wks (n=29) B. Placebo (n=27) Sham		Outcome measures: Symptom problems and severity Amount voided SF-36 (Quality of life) Fluid intake Follow Up: 12 wks Results: Significant decreases between baseline and 12 wks follow up in the amount voided, symptom problems and severity and on all 8 SF-36 scales. There was no	Acupuncture points: Unclear Laser parameters: Unclear

(Contd)

(Contd)

Table 3 Continued

Study	Participants	Groups/intervention	Outcomes	Comment
Butkovic et al [38]	Post-operative Nausea and Vomiting (PONV) $n=120$ children ASA I and II, scheduled for hernia repair, circumcision or orchidopexy	<p>A. Laser acupuncture Wavelength: 780nm Continuous wave Power: 20mW Dose: 1 J per point; P6 point 15 min prior to the induction of anesthesia and saline infusion</p> <p>B. Metoclopramide 0.1 mg/kg i.v. and sham laser</p> <p>C. Sham laser Not specified</p> <p>All groups: Post-operative analgesia with oral midazolam (1 mg/kg)</p>	<p>significant effect of fluid intake. There were no significant differences between the groups on any of the measures. Authors' conclusion: Negative</p> <p>Outcome measures: Patients assessed for symptoms of retching and vomiting at 2, 6 and 24 hrs post-operative</p> <p>Results: There was no statistical difference between the laser acupuncture and metoclopramide groups in the occurrence or timing of vomiting. The frequency of vomiting was higher in the control group in comparison to the laser acupuncture and metoclopramide groups.</p> <p>Authors' conclusion: Laser acupuncture is equally effective as metoclopramide in preventing PONV in children</p>	<p>Acupuncture points: Appropriate</p> <p>Laser parameters: Appropriate</p>
Ebneshahidi et al [26]	Chronic tension headache $n=50$ (40 male, 10 female)	<p>A. Laser acupuncture ($n=25$) [5 male, 20 female; mean age 33 yrs (25–52)] Wavelength: 830nm Continuous wave Power: 39mW/cm² (max) Dose: 1.3 J per point (13J/cm²) LU7, L14, GB14, GB20 bilaterally (8 points in total) for 10 sessions, ×3 per week. Vertical contact with pressure</p> <p>B. Placebo ($n=25$) [5 male, 20 female; mean age 38.6 yrs (26–54)] As above except, output power was set to 0 Both groups: No analgesics administered</p>	<p>Outcome measures: Headache intensity (VAS), duration of attacks (hrs), number of days of headache/month</p> <p>Follow up: Baseline, 1 mo, 2 mo, 3 mo</p> <p>Results: Significant changes over time in both groups. The treatment group was significantly superior to the placebo group in all outcomes, at all time points Authors' conclusion: Positive</p>	<p>Acupuncture points: Appropriate</p> <p>Laser parameters: Appropriate</p>

None of these studies demonstrated any significant effect of laser acupuncture compared with placebo, which would suggest no benefit from laser acupuncture in the treatment of this condition. However, and notwithstanding the high methodological quality of two of these studies, the combinations of irradiation parameters used by these investigators were considered to be inadequate to provide any clinical benefit: power outputs ranged from 0.7–12 mW, while dosages per point ranged from 0.0936–0.6 J. Beyond this, this group typically used non-contact treatment (with the laser held 1 mm from the target tissue) which was also considered inappropriate as it would limit penetration of light into the tissue. There was therefore insufficient evidence upon which to make a decision as to the effectiveness of laser acupuncture in the treatment of lateral epicondylitis.

4.7. Clinical effectiveness of laser acupuncture: other conditions (see Table 3)

4.7.1. Post-operative nausea and vomiting

One low quality [38] and one high quality RCT [22] studied the effectiveness of laser acupuncture in comparison to placebo in reducing post-surgical nausea and vomiting in children. Both studies applied laser to the P6 acupuncture point. Schlager et al [22] found that a dose of 0.3 J point applied bilaterally 15 minutes prior to, and repeated 15 minutes after, surgery was significantly more effective than placebo at reducing the incidence of vomiting (RR: 0.06; 0.01–0.29). In a similar study, Butkovic et al [38] found that a dose of 1 J applied 15 minutes before surgery significantly reduced the incidence of nausea and vomiting during the first 2 hours post-operatively, when compared with placebo laser (RR 0.21; 0.07–0.66). It was therefore concluded that there is moderate evidence that the use of laser acupuncture is more effective than placebo in reducing post-operative nausea and vomiting.

4.7.2. Smoking cessation

A single high quality study by Yiming [19], using a follow up time of 3 months, found that 12 sessions of laser acupuncture to five auricular acupuncture points made no difference to the smoking habits of a group of adolescent smokers, when compared with those receiving placebo treatment (RR: 1.03; 0.57–1.84). The laser parameters used in this study were not specified, and therefore it was not possible to estimate the actual dosage employed. There was therefore insufficient evidence upon which to

make a decision as to the effectiveness of laser acupuncture in smoking cessation.

4.7.3. Nocturnal enuresis

Radmayr et al [39] compared the effectiveness of laser acupuncture to medication intervention in preventing nocturnal enuresis. Both groups had a significant reduction in bedwetting and although comparison between groups slightly favored the desmopressin group (RR: 1.62; 0.41–6.34), there was no significant difference between groups. These authors provided insufficient data on the laser parameters used to stimulate the acupuncture point treated in this study; there was therefore insufficient evidence upon which to make a decision as to the effectiveness of laser acupuncture in the management of nocturnal enuresis.

4.7.4. Interstitial cystitis

O'Reilly et al [40] undertook a double blind study using a sample of female patients with interstitial cystitis. It was found that 12 weeks of laser acupuncture applied to the SP6 acupuncture point was no more effective than placebo intervention in easing symptoms of interstitial cystitis (SMD: –1.00; –3.11–1.11) at 3 months, or in reducing urinary output (SMD: 1.48; –21.8–24.9) at 1 month or 3 months (SMD: 9.07; –13.15–31.3). The laser device used in this study was specifically produced for daily home use by patients (stimulation of the SP6 acupuncture point for 30 seconds). However, once again the irradiation parameters used were not specified; there was therefore insufficient evidence upon which to make a decision as to the effectiveness of laser acupuncture in the management of interstitial cystitis.

4.7.5. Headache

Ebneshahidi et al [26] compared the effectiveness of ten sessions of laser acupuncture to placebo in the treatment of patients ($n=50$) with chronic tension headaches. Laser acupuncture, applied bilaterally at eight points, using a dose of 1.3 J point, was found to be significantly more effective than placebo in reducing the intensity, duration and number of headaches suffered. There is therefore limited evidence that laser acupuncture applied at appropriate irradiation parameters is effective in the treatment of chronic tension headaches.

5. Discussion

This systematic review assessed the evidence to support the clinical effectiveness of laser acupuncture,

principally focusing on pain management. The key finding from this review is that there is moderate evidence to support the use of this therapy in the treatment of myofascial pain when clinically appropriate irradiation parameters (i.e., power outputs of at least 10mW and dosages of at least 0.5J per point) are applied. Beyond this, there is a moderate level of evidence (one high and one low quality trial) to support the use of laser acupuncture to manage post-operative nausea and vomiting and limited evidence of effectiveness (one low quality study) for laser acupuncture in the relief of chronic tension headache. Because of the lack of RCTs employing clinically appropriate laser irradiation parameters, it is not possible to come to any definitive conclusion about the effectiveness of laser acupuncture in the treatment of lateral epicondylalgia, nocturnal enuresis, or interstitial cystitis, nor for smoking cessation.

For the purposes of this review, clinical appropriateness of the intervention was used as an additional means of assessing evidence of the effectiveness of laser acupuncture. This included assessments of the appropriateness of the laser treatment parameters employed, as well as of the acupuncture points stimulated. The latter was undertaken by an experienced acupuncturist, and acupuncture points selected for the studies reviewed were deemed appropriate for the condition treated. However, the difficulties in making such a determination—given the range of possible combinations which would be considered acceptable—and in prescribing acupuncture points on a formulaic basis as part of a clinical trial to standardize treatment for all subjects, should be noted [41]. Determination of appropriateness of laser irradiation parameters was undertaken by one of the authors with extensive experience in laser therapy as a researcher and clinician and based upon recent recommendations by the World Association of Laser Therapy (WALT) [16]. Given the potential permutations of combinations of laser irradiation parameters (see Tables 2 and 3), we focused on setting thresholds for two of the most important parameters: radiant power output (specified average power output in mW) and dosage (specified here in Joules per point). In the case of the former, 10mW was considered to represent a clinically appropriate threshold value for average power output, while for the latter 0.5J per point was derived from the minimum dosage recommended by WALT (i.e., 1 J per point $\pm 50\%$).

While the results of the current review would support the use of such thresholds (i.e., positive studies were associated with the use of higher power outputs and dosages), there are limitations to such an approach which need to be recognized. In the first instance, the quality of reporting of

laser irradiation parameters in the studies reviewed was highly variable: in some cases it was not possible to accurately determine the power output of the laser device used, or to estimate the dosage applied to stimulate acupuncture or trigger points. For example, in one of the earlier (and most cited) studies in this area, the research group simply indicated that Helium-Neon laser was applied for 15 seconds per point [27]. Secondly, and perhaps more importantly, while the mechanisms of action underpinning laser therapy for stimulation of tissue repair have been extensively investigated and are largely well known and accepted [42], those underpinning laser acupuncture remain occult [7,43]. Thus while determination of appropriate or optimal treatment parameters for other types of laser therapy treatment can be informed by experimental findings which provide a scientific rationale for parameter selection [44], this is currently not possible for laser acupuncture. Therefore, although the current review provides some evidence of effectiveness which depends upon power output and dosage, it does not elucidate the likely mechanisms of action. Additionally, the current findings do not provide any clear evidence as to the potential relevance of other irradiation parameters such as wavelength and pulse repetition rate.

In keeping with findings from systematic reviews in other areas of physical medicine and rehabilitation, and in complementary and alternative medicine, the quality of the studies identified for the current review was variable; only five of the 18 papers reviewed were rated as 'high quality' based upon van Tulder scores. Of these higher quality studies, only two were deemed to have used clinically appropriate laser irradiation parameters [19,22]; thus high internal validity (determined here by a well-accepted means of assessing study quality) [12], does not necessarily ensure the external validity of a study. Equally, it is important to recognize that the majority of papers underpinning the current recommendations are based upon 'lower quality' research trials.

6. Summary and Implications for Future Research

Based upon the current review, laser acupuncture can be recommended as an effective treatment (moderate level of evidence) for the reduction of myofascial pain, at least when irradiation is applied at power of at least 10mW and a dosage of at least 0.5J per point. For the treatment of post-operative nausea and vomiting, there is moderate evidence to support the use of laser acupuncture, applied to the P6 acupuncture point at an intensity of at least

10mW and a dosage of at least 0.3J per point. There is limited evidence (one positive clinical trial) [24] of the clinical effectiveness of laser acupuncture in the treatment of chronic tension headache. Findings in other areas are less conclusive (insufficient evidence), due to the limited numbers of published studies available, and (particularly in the case of lateral epicondylitis) the application of inappropriate laser treatment parameters. Beyond this, the wide heterogeneity of laser parameters employed in the studies reviewed precludes further more definitive recommendations in terms of treatment parameters. However, these results highlight the critical importance of threshold intensities and dosages to the clinical effectiveness of laser used as an alternative to needles for acupuncture treatment.

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